INTERSENSORY TRANSFER IN FORM RECOGNITION

2 5 T

By

HENRY FRANK GAYDOS

A DISSERTATION PRESENTED TO THE GRADUATE COUNCIL OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY

UNIVERSITY OF FLORIDA

August, 1953

ACKNOWLEDGMENT

The writer wishes to express sincere appreciation to the members of his Supervisory Committee, Dr. J. C. Dixon, Chairman, Dr. R. J. Anderson, Dr. Henry Wunderlich, Dr. W. W. Ehrmann, and Dr. T. Lynn Smith for freely giving counsel when it was needed, and withholding it when it was not, in order that the writer might justifiably claim the following work as his own.

Gratitude is due also to Dr. E. D. Hinckley, Mrs. Faye P. Ricker, and Dr. R. H. Waters, who helped obtain subjects for this experiment, and especially to the subjects themselves.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF ILLUSTRATIONS

Chapter I

INTRODUCTION AND STATEMENT OF THE PROBLEM

The specific purpose of this study is to investigate the question of whether or not a person can learn to discriminate and identify the individual members of a set of bidimensional shapes by means of one sensory modality, and then correctly identify these same shapes through another sensory modality, without having to repeat the entire learning process. The sense modalities to be employed are those of touch and sight. The term "touch" will be used to designate the complex of cutaneous and kinesthetic cues which the subjects receive by manipulating the stimulus objects with their hands. "Sight" will be understood to mean visual form perception.

This problem, of course, falls under the general heading of transfer of training, which in turn falls under the very broad topic of learning. The present study is not intended, however, to be used in an attempt to lend support to any of the controversial issues in general learning theory. It is intended, rather, to explore an area of psychology in which very little experimental work has been

done. The reason for the lack of experimental investigation of transfer of training across modalities is quite obscure. However, one might suppose that either the topic in question has such little significance to psychological theory that few have thought it worthwhile to investigate, or else the phenomenon is so well taken for granted that no one cares to undertake a demonstration of the obvious.

That the latter case may be true is hinted in a footnote written by McGeoch (6, p. 406).

> "There is also some transfer across modalities. Some of it may be regarded as sensory generalization, while some of it may be mediated by symbolic processes. An instance of the latter is the fact that objects with which one's first acquaintance is visual may be recognized by touch, and vice versa."

This footnote is McGeoch's treatment of intermodal transfer in its entirety. He makes no further reference to this topic in a volume which presents an exhaustive survey of the study of human learning. What is more, no mention of the problem could be found in the standard reference works of either Woodworth (9), or Stevens (8).

In spite of, or perhaps because of, its being hitherto neglected, this problem seems to deserve an experimental investigation. Whether or not transfer across sensory modalities is taken for granted, it certainly merits consideration in systematic psychological theory. If it is taken for granted, then it must be pointed out that the history of science has shown repeatedly that there is often more to the

"obvious" than meets the eye.

Although no studies could be found which dealt specifically with intersensory transfer of form recognition, the notion of the existence of some unifying factor common to all the senses is very old. As might be expected, the idea goes back to Aristotle and his Sensus Communis.

A more recent exponent of sensory unity was Hornbostel, cited in Hartmann (3), who proposed "brightness" as a supra-sensory factor. That is, brightness is not merely an attribute of visual sensation, but is an experience which is common to all senses. To prove his point, Hornbostel had a large number of subjects equate a shade of grey, a tone, and an odor on the basis of their common "brightness" qualities. The subjects apparently agreed much more closely in their choices than chance alone would dictate. This was interpreted by Hornbostel as being demonstrable positive evidence for unity among the senses.

Ryan (7), in a review of the work done on the interrelations of the sensory systems, refers to studies by Urbantschitsch, Kravkov, Johnson, Hartmann, and others. These studies dealt with the increase of sensitivity in one sense modality as a result of applying a stimulus to another sense modality. For example, Urbantschitsch found that certain auditory stimuli seemed to lower the threshold for visual color sensitivity.

Even though the studies mentioned above indicate some kind of relationship between the senses, they are not too relevant to the present experiment, except in pointing out the kind of work which has been done in that area. The stimuli which were employed may be classed mainly as elementary sensory attributes such as brightness, color, pitch, and so forth. Ryan says in his conclusions,

> "We find that the bulk of more or less integrated research upon the interrelations of the senses has been concerned with highly abstract and artificial interactions at what used to be called a 'purely sensory level'. ...instead of dealing with the kind of perceiving of most interest in everyday living, the perceiving of objects, scenes, events, and situations, consideration is artificially limited to certain aspects of objects abstracted from the total situation and from all 'meaning'."

More closely akin to the present experiment is a study by Cutsforth (1), who investigated the relationship between tactual-kinesthetic and visual perception of size. He had his subjects try to reproduce visually, by means of an adjustable frame, the size and proportions of five wooden rectangles, which they were allowed to feel but could not see. The tactual impressions were received in two ways; by "passive" touch, and by "active" touch. In passive touch, the subject merely placed his hand on the rectangle, with a minimum of movement. In active touch, the subject traced the length and width with his fingers.

It was found that, in general, the size of the tactually perceived rectangle was both underestimated and over-

estimated, although the former discrepancy occurred more often. Also, the visually reproduced rectangle was consistently closer to the proportions of a square than the standard figure. The same types of errors in size and proportion were made when subjects had to reproduce a visually perceived rectangle, although the errors were smaller in magnitude.

With regard to active versus passive touch, the discrepancy between two perceptions of the same size was greater when the active method was employed. That is; the passive method yielded results that were less variable within each individual's performance. From this data, Cutsforth concluded:

> "A. The active method of tactual exploration favors a more analytical perception of form, by emphasizing the discreteness of height and width.
>
> "B. The passive method of exploration favors a tactual perception of form as a whole in which height and width are included not as discrete aspects, but as a proportion."
>
> Some of his more general conclusions are:
>
> "The tactual perception of proportion is the most reliable basis upon which to construct a visual equivalent.
>
> "The 'tactual' perception of size and form is exclusively a visual configuration.
>
> "No truly tactual patterns were found in the tactual perceptions of form.
>
> "The perceptions of 'tactual' form were carried in visual imagery.
>
> "Tactual qualities provide 'texture', 'body', and

> subjective reference, but form, extent, position, and organization are visual.
>
> "From the results of this experiment it is necessary to conclude that the tactual field does not function, in seeing individuals, separately from the visual. The two modalities are not, and cannot, be distinct for the purposes of perception. It is an error to speak of a pure tactual or tactual-motor perception."

From the point of view of the present writer, the certainty with which the above conclusions were stated does not seem warranted on the basis of the evidence presented. While it may be granted that form is generally perceived in visual terms, and that vision is almost inextricably bound up with tactual-motor activity, to deny the tactual-motor senses any independence in form perception seems to be presumptuous.

Worchel (10) studied tactual form perception in blind, and blindfolded seeing subjects. He found that the seeing subjects were very significantly better than the blind subjects in the reproduction by drawing, and verbal description of the stimulus form. Subjects who had been accidentally blinded performed better than the congenitally blinded, and there was a high correlation between the age of onset of blindness and the accuracy of performance.

On the other hand, when tested for tactual discrimination and recognition of the stimulus forms, the blind and the seeing subjects performed equally well.

Worchel's study shows that a visually recognizable reproduction of a tactually perceived form is dependent upon

visual development. That verbal description of the form is so difficult for blind subjects may be more a matter for semantics than lack of vision, since our language is based mainly upon visual concepts. However, the ability to distinguish one form from another, and to recognize forms by tactual means is obviously not dependent upon visual development, as the performances of Worchel's blind subjects will testify. On the basis of this evidence, Cutsforth's conclusion, that form perception is exclusively a visual function, is contradicted.

Assuming that perception of form by touch alone is possible, the problem still remains as to how much correspondence there might be between the perception of a given form by touch, and a visual perception of the same form. Must the object be perceived through both senses before any degree of correspondence can be built up, or can the concept of a given form be constructed through one modality, and be immediately recognizable through the other modality?

A partial answer to this question might be gotten if it can be shown that discrimination and recognition of a number of forms can be learned through touch, and then transferred to sight without appreciable relearning. The converse can also be tested; that is, to learn by sight and transfer to touch. If this can be shown to occur, then we shall have positive evidence that form is not the exclusive property of

any one sensory modality, but is instead relatively independent of its mode of perception.

It was felt that the specific forms to be used in the proposed experiment should meet certain criteria. To avoid introducing too many variables, the forms should be bidimensional. The edge contour should be the sole differentiating characteristic among the various stimulus objects, and shall hereafter be referred to as "shape", since the term "form" has acquired a rather broad array of connotations. The objects themselves ought to include some shapes which would be similar to relatively familiar geometric shapes, and some which would be relatively unfamiliar. In other words, the task of discrimination should be more difficult than merely counting three sides to distinguish a triangle, and four sides to distinguish a square. In addition, each shape would need a label by means of which the subject could communicate its identity to the experimenter.

Using stimulus objects described above, an experiment could be set up as follows. The subjects to be employed would be divided into two groups, designated as Group I, and Group II. Group I would learn to discriminate and recognize the given shapes by touch. This is condition A_1. Then Group I would be tested for recognition by sight, condition B_2. Group II would, conversely, learn by sight, condition B_1, and be tested for recognition by touch, condition A_2.

Schematically:

Group I - first A_1, then B_2

Group II - first B_1, then A_2

Assuming that the two groups have equal learning ability; under conditions of no transfer, the learning scores of Group I on A_1 should equal the scores of Group II on A_2. Also, under conditions of no transfer, the learning scores of Group II on B_1 should equal the scores of Group I on B_2. The conditions for intermodal transfer would thus be fulfilled.

With the above design, it would also be possible to test the hypothesis that learning might be more difficult through one modality than through the other. This would show up in a difference in learning scores between A_1 and B_1. If vision has become the dominant modality in our perception of form, then we should expect greater difficulty in learning by touch.

In the event that transfer does occur, it would also be possible to determine the relative efficiency of transfer between going from touch to sight, and from sight to touch. A significant difference between A_2 and B_2, and the direction of the difference, would be indicative here.

The problem may now be stated concisely in the form of the following questions.

(1) Can the ability to recognize certain shapes be transferred across modalities, from touch to vision, and vice versa?

(2) Is there any difference between using vision and using touch in connection with the relative difficulty in learning to discriminate and recognize certain shapes?

(3) Should transfer occur, is there any difference in the relative efficiency of transfer between going from touch to vision, and from vision to touch?

(4) Should transfer occur, is there any relationship between the degree of transfer and the rate of initial learning?

Chapter II

METHOD

Subjects

Eighty-six subjects were employed in this study, and they include student volunteers from the introductory psychology courses, graduate students majoring in psychology, and psychology faculty members at the University of Florida. These subjects were divided equally between groups I and II, and the two groups were equated as nearly as possible for age, sex, and educational level. A description of the pertinent characteristics of each group is given below in Table I.

Apparatus

The essential equipment consisted of twelve pieces of one-eighth inch thick Masonite cut into different shapes. These shapes are shown at one-half their actual size in Figure 1. To each of these pieces was given a one-syllable man's name, and each piece had its name marked on the back. The choice of names was made on the basis of their being familiar to most people, and presumably easy to remember.

In order to furnish a reference point by which the subject could orient himself to the spatial positions of the

TABLE I

DESCRIPTIVE CHARACTERISTICS OF THE SUBJECTS
WITH REGARD TO AGE AND EDUCATIONAL LEVEL

	Group I			Group II		
	Men	Women	Total	Men	Women	Total
Number	23	20	43	23	20	43
Age Range	18-40	18-38	18-40	18-44	17-37	17-44
Mean Age	25.0	21.3	23.3	24.0	22.7	23.4
S. D.	7.68	5.57	6.93	6.25	5.29	5.74
Freshmen	1	5	6	1	5	6
Sophomores	8	5	13	4	4	8
Juniors	2	6	8	6	4	10
Seniors	5	3	8	7	5	12
Graduates	6	1	7	5	2	7
Faculty	1	0	1	0	0	0

shapes, a small notch was cut in the edge of each piece. Also, since Masonite has one rough side and one smooth side, the subjects were able to distinguish between the upper and lower sides of each piece; the smooth side being considered the top. By virtue of their having uniform thickness, the shapes may be considered to be essentially bi-dimensional.

A vision screen, shown in Figure 2, and suitable blanks on which to record the subjects' responses made up the remainder of the equipment.

Procedure

The gist of the procedure was to have each subject learn to recognize each shape by name through the use of one sense modality, and then test for transfer of recognition through another sense modality. The initial learning task was carried out to a criterion of two successive errorless trials, and the test of transfer was carried to one errorless trial. Group I learned by touch and transferred to sight. Group II learned by sight and transferred to touch. Under these conditions, each group served as the control group for the other.

A. Group I

Each subject was given the following set of instructions. These were not read verbatim, but were given rather informally. Care was taken to make sure that the subject understood exactly what was to be done.

> "I have here twelve different shapes cut out of thin board material. Each one has a name; a one-syllable man's name that should be easy to remember. Now I want you to put your hands through these sleeves, and I will give you these pieces one at a time, tell you what the name is, and let you feel the shape for a few seconds. Each shape has a small notch cut in the edge, and this notch will always be placed toward you, so that you know the piece is in the same position each time I put it down.
>
> "After we have gone through the whole set one time, I will continue to give you the pieces, but then I want you to try to tell me what their names are. If you have no idea what the name is, just say that you don't know. However, if you can make a fair guess, then you should do so. After you have given your answer, I will tell you the correct name so that you will know whether you were right or wrong. We will keep going until you can name each piece without error. However, the shapes will not be given in the same order each time, so don't try to learn them in any order.
>
> "After you have learned to identify each shape by the way it feels, I will then let you look at them to find out whether you can identify them by sight alone."

The shapes were then presented to the subject in a random order. The order of presentation was not strictly random in a statistical sense, but was sufficiently varied to break up any regular patterns which might permit learning of sequences. After the entire set of twelve had been presented in the introductory trial, the subject was informed that he must begin to call out their names. Thereafter the pieces were presented without interruption. Although the entire set was given to the subject in each trial, he was not told when one trial ended and the next began. This procedure continued

until the subject completed two consecutive trials without error. At this point, the subject was informed that he must now try to identify each piece by sight, without being allowed to touch them. The shapes were then placed before him, one at a time, on a background consisting of a piece of white paper. He would give his response, and would then be told the correct name of the piece. This was continued until the subject completed one trial without error.

B. Group II

The instructions and procedure were generally the same as for Group I, except that Group II initially learned to distinguish all the shapes by sight, and was then tested for transfer of recognition to the sense of touch.

Recording

Responses were recorded on mimeographed forms, a sample of which is shown in the appendix. A "plus" sign indicates a correct response, and a "minus" sign indicates a "don't know" response. If the subject made an incorrect guess, the name he called out was indicated by the code number assigned to it.

The performance of each subject was measured both by the number of trials and by the number of errors which occurred before the established criteria of proficiency were reached. However, all the statistical work was done in terms of the number of errors. This was done because the number of errors exceeded the number of trials to a degree which offered a much

greater range of variability, and allowed more reliable discrimination between performances.

There was no time limit set for any part of the experiment except for the introductory visual exposure of the stimulus shapes to Group II. Here, each shape was shown, in immediate succession, for five seconds after its name was given to the subject for the first time. This duration was somewhat arbitrary, but nevertheless was judged to be long enough for the subject to observe the main features of the stimulus object. Beyond this, it was felt that any limits set on exposure times would be purely arbitrary, and the setting of such limits might introduce more variables than it presumably controlled. That is, the relation between exposure times for touch and sight which would allow an equivalent degree of exploration through each sensory modality was unknown. Therefore, except for the very first visual presentation discussed above, each exposure was terminated as soon as the subject gave his response, and the next stimulus shape was presented immediately thereafter.

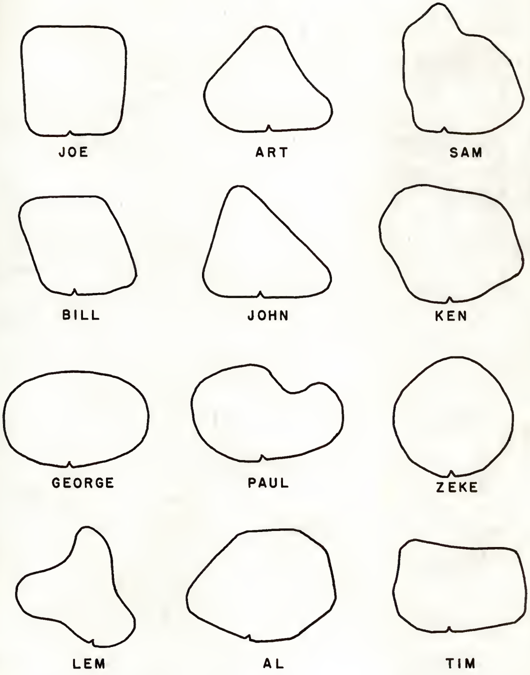

Fig. 1. The stimulus shapes, shown one-half actual size.

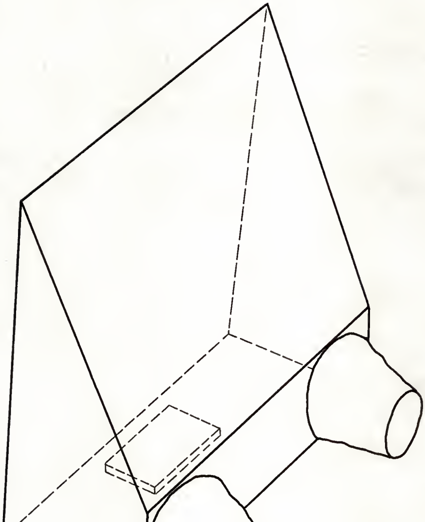

Fig. 2. Screen to hide stimulus shapes from the subject's view during initial learning by touch and test of transfer by touch.

Chapter III

RESULTS

In connection with the main problem, that is, to find out whether the ability to recognize certain shapes would transfer from touch to vision, and vice versa, the following information came to light. A test of significance between the mean number of errors made by Group I, in learning the task by touch, and the mean number of errors made by Group II in recognition by touch, after learning by sight, yielded a t-ratio of 11.89. The difference between the mean number of errors made by Group II, in learning by sight, and the mean number of errors made by Group I, in recognition by sight, after learning by touch, yielded a t-ratio of 10.93. These differences are very highly significant even beyond the 0.1% level of confidence. It would appear from these figures that the evidence for transfer under the conditions of this experiment has been clearly established.

To test the relative difficulty between learning by sight and learning by touch, the mean number of errors of Group I, in learning by touch, were compared with the mean number of errors of Group II, in learning by sight. These

means were 39.65 and 34.93, respectively, but the difference turned out to be not significant at the 5% level of confidence, the t-ratio being 1.154.

Although the means of the errors in learning the task do not differ significantly from Group I to Group II, the mean difference between these groups with regard to their errors of recognition in the test for transfer is significant at the 1% level of confidence. The number of errors is greater in recognition by touch than in recognition by sight, the t-ratio being 3.196.

A statistical summary of the results discussed above is shown in Table II. It must be mentioned, however, that before any of the figures found in the tables were computed, the data were analyzed for any significant differences between the performances of men and women. This was done by obtaining the t-ratios between the means of error scores of men and women within Group I and Group II. The highest t-ratio thus found was 0.867, which hardly even approaches significance at the 5% level of confidence. This being the case, it was deemed permissible to treat the data within each group without regard to the sex of the subjects.

In addition to the above, a number of product-moment correlations were computed. First of all, it seemed desirable to investigate the relation between some measure of general intelligence, and performance on the experimental

task. Since scores on the American Council on Education Psychological Examination, 1949 College Edition, were available for twenty-two subjects in each group, these A. C. E. Total Scores were correlated with the number of errors in learning, and also with the number of errors in recognition on the test of transfer.

Another question to be explored was that of the relation between performance on the initial learning task, and performance on the test of transfer. Consequently, a correlation coefficient was obtained for the number of errors on the initial learning task versus the number of errors on the test of transfer. This was done for each group, using the data on all forty-three subjects within each group.

The obtained correlation coefficients are shown in Table III, together with their respective t-ratios. However, the t-ratios indicate that the correlations are not great enough, for the given number of cases, to differ reliably from zero.

TABLE II

SUMMARY OF COMPARISON OF MEANS

Measure	Mean	S.D.	t-ratio
Errors in learning by touch, Group I	39.65	18.55	11.89
Errors in recognition by touch, Group II	4.58	4.60	
Errors in learning by sight, Group II	34.93	19.39	10.93
Errors in recognition by sight, Group I	2.02	2.54	
Difference between errors in learning by sight and errors in learning by touch	4.72	---	1.154
Difference between errors in recognition by sight and errors in recognition by touch	2.56	---	3.196

TABLE III

SUMMARY OF CORRELATIONS

Measure	N	r	t-ratio
A. C. E. Total Scores correlated with errors in learning by touch; Group I	22	-.388	1.883
A. C. E. Total Scores correlated with errors in learning by sight; Group II	22	-.293	1.371
A. C. E. Total Scores correlated with errors in recognition by sight; Group I	22	-.149	0.674
A. C. E. Total Scores correlated with errors in recognition by touch; Group II	22	-.392	1.906
Errors in learning by touch correlated with errors in recognition by sight; Group I	43	.149	0.855
Errors in learning by sight correlated with errors in recognition by touch; Group II	43	.269	1.743

Chapter IV

DISCUSSION

Interpretation of Results

The statistical results leave little doubt that a high degree of transfer has taken place between the visual and the touch sense modalities. Much less obvious are the processes which occurred in what has been designated as "transfer".

Under the conditions of the problem, all subjects were required to attain the same criterion of initial learning, and the number of errors made during learning was taken as the measure of difficulty experienced in reaching that criterion. Group I made a mean error score of 39.65 in learning to identify the shapes by touch. Since Group I and Group II are matched, we may assume that Group II, under the same conditions, would have made a mean error score that would not have been significantly different from 39.65. However, Group II was able to reach the criterion for recognition by touch after making a mean error score of only 4.60. This great difference between mean error scores is attributed to the fact that Group II previously learned to identify those same shapes by sight, and the ability to identify by

sight transferred over to touch. The same principle holds for the transfer found in Group I.

The question is raised as to just what is contained in this transferred "ability to identify". One assumption might be that the subjects acquired skill in learning to discriminate and identify the given forms, and that the test for transfer was simply an accelerated process of relearning. More explicitely, the subjects first learned to associate a set of appropriate verbal responses to a set of visual stimuli, and then had to learn to make the same responses to a different set of stimuli, i.e., touch stimuli.

While the condition of learning to associate old responses with new stimuli is conducive to transfer, even this does not account for the results. An examination of Table IV reveals that fourteen subjects in Group I and seven subjects in Group II made no errors at all on the test for transfer. This means that for these subjects the association between the old response and the new stimulus was formed at once, and needed no reinforcement. Here arises a point which may have some theoretical significance, but further discussion will be deferred for the moment.

Taking up the topic of the relationship between the mode of perception and rate of learning, Table II shows that fewer errors were made in learning by sight than in learning by touch, but this difference is not statistically reliable.

TABLE IV

FREQUENCY OF ERRORS IN TRANSFER
AMONG SUBJECTS OF GROUPS I AND II

Number of Errors	Number of Subjects	
	Group I	Group II
0	14	7
1	13	4
2	1	4
3	6	4
4	5	3
5	0	6
6	1	5
7+	3	10

The ontogenetic development of form perception seems to depend upon the integration of visual and tactual-motor cues, but since the growing individual normally comes to depend more and more upon vision, it might be supposed that vision would eventually outstrip touch in the ability to perceive form. If vision were the modality most highly developed for the perception of shape, then it would be reasonable to expect more efficient learning of shape discrimination through this modality. Here then, is evidence to weaken the case for visual dominance, and suggests a tentative hypothesis.

It is possible that the importance of shape as a distinguishing characteristic in the visual perception of an object has been overemphasized. It may be that in our everyday observation of things, form is hardly ever abstracted completely from the context of complex factors making up a visual perception. That is, our visual recognition of objects is based upon brightness, color, size, perspective, and movement, all in various combinations, as well as upon shape. Hebb (4) cites Senden's study of congenital cataract patients who had their vision restored to them, but who had to go through a long period of learning before they were able to perceive form. Color was persistently dominant over form in the earlier stages of visual development.

Recognition by touch may also be based upon a complex

of shape, texture, size, weight, hardness, temperature, and movement. However, the extent to which the shape of an object may dominate its other characteristics will, of course, vary from one object to another, and quite probably from one observer to another. The point is: if all other factors are controlled so that shape, and to some extent size, are the only characteristics by which objects may be differentiated, then both vision and touch might be reduced to a more or less equal footing.

In the present experiment, all differences among the stimulus objects except shape and size were controlled insofar as it was possible. Since the shapes were so varied, it was not possible to equalize the sizes, because there was no way to predict the basis upon which a subject might make a size judgment. In other words, a subjective judgment of size might be based upon length, width, area, relative proportions, or any combination of these. Nevertheless, in view of spontaneous descriptive comments offered by most of the subjects, the experimenter is certain that it is shape, and not size, that was the primary distinguishing characteristic.

Whether the interpretation offered above is correct or not, the evidence is fairly conclusive that, under the conditions of the experiment, subjects using touch performed as well as subjects using vision in learning to discriminate and identify the given shapes.

In examining the relative efficiency of transfer between going from touch to sight, and from sight to touch, the former condition turned out to be significantly superior. There seems to be no ready explanation for this occurrence, nor of its relationship to the equivalent rates of learning through the two modalities.

If speculation is in order, it may be that fewer cues were employed in learning the task visually than in learning it tactually. Whereas the cues employed in learning by touch might have included all the cues needed for visual recognition, perhaps learning by sight required a minimum of cues which were simply not sufficient to allow recognition by touch. Furthermore, the novelty of having to learn something by touch might have given Group I the incentive to be more thorough in their task. On the other hand, it is possible that in spite of all precautions taken to control such an event, the stimulus objects may have presented some cues which were available to vision, but not to touch.

Since there is no concrete evidence available to support the foregoing speculations, the reasons for the occurrence of the phenomenon must, for the present, remain unknown. It must suffice to note merely that transfer from touch to vision appears to be more efficient than transfer from vision to touch.

One interesting piece of information to come out of this study is the lack of any significant correlation between

the number of errors made during learning, and the number of errors made on the test for transfer. According to this, the degree of transfer was independent of the initial learning rate. This might be interpreted as further evidence that transfer, in this case, was not a matter of relearning which had been accelerated by practice on the initial learning task. Instead, transfer occurred rather abruptly, and seemed to depend upon completeness of initial learning rather than rate of learning.

Evidence to support this contention comes from the fact that the great majority of errors made on the test for transfer were connected with the shapes which were learned last in the initial task. In spite of the subjects' having reached criterion, the last learned shapes might have been correctly named through a process of elimination rather than on the basis of true recognition. This is supported by what appears to be transfer of specific errors. That is, if two shapes were consistently confused in the learning process, the identical type of error would tend to appear in the test for transfer. Further discussion of this point in the section on Qualitative Observations gives specific examples.

Perceptual discrimination, and rate of learning, are very frequently used measures of general intelligence. Consequently, one would expect performance on the experimental task to correlate with some standard measure of intelligence. Since A. C. E. scores were available on twenty-two subjects

in each group, the correlations shown in Table III were computed. None of these correlations is reliably different from zero, but the number of subjects was too small, and since all the subjects were college students, the range of intelligence was too narrow to allow a crucial test. Under these circumstances, no conclusions about the role of intelligence in the performance of the experimental task are warranted.

There is, nevertheless, one point to be mentioned in the interest of further investigation. Halstead (2) differentiates between tests that have high and low factor loadings on what he calls "C" or "The Central Integrative Field". Those with high factor loadings are highly correlated with the combination of native intellectual capacity and the fund of past experience in a given individual. Those with low factor loadings tend to exclude past experience to a large extent. One such test used by Halstead is a modification of the Sequin-Goddard performance test, in which the subject must fit the blocks in their proper places while he is blindfolded. Halstead says (2, p. 51),

> "Here again we are faced with a test in which a background of well-organized habits (C) can contribute little to an early rapid solution simply because no such background exists. The subject, who normally employs visual cues in performing matching problems of the type presented here, encounters for the first time a situation requiring the use of tactual cues."

Since the task employed in this experiment is similar in some ways to Halstead's, any future attempt to relate

performance on this task to general intelligence must take into account the foregoing discussion.

Qualitative Observations

The following comments are based upon qualitative observations which were made by the experimenter during the experimental sessions. They are not intended to add anything to the final conclusions, but are intended rather to convey certain impressions and nuances which may be useful in formulating and testing new hypotheses.

Verbalization seemed to play an important role in the learning task for many subjects. The stimulus shapes were often given verbal associations to aid in differentiation and recognition, and these associations were of several types. First of all, the shapes were associated with common geometric figures and terms. "This is a triangle," or "This is a square." Familiar geometric terms were not adequate to describe all the figures, however, and subjects would then resort to associations such as, "Lem is like a floppy hat." These memory aids varied in complexity, but were associated only with the perceived shape. A more complex type of association was sometimes used to link the shape and the name together. For example, "John is a triangle, because 'John' reminds me of 'John's other wife', which reminds me of the 'eternal triangle'." This last type of association seems to have been the most effective aid in learning, both for touch

and for sight.

As might be expected, the shapes which were most ambiguous were the most difficult to learn. "Ken," who had almost no distinguishing features, seemed to call up very few associations, and was usually the last one to be learned.

Of course, the extent to which associations were made depended upon the subject as well as the particular stimulus shapes. It is probably significant that four subjects, not included in the final data, were unable to complete the initial learning task, and they said that they simply could not learn to distinguish one shape from another because they could not associate them with anything.

There were a few subjects who claimed that they employed no verbal associations at all, but were able to carry mental images of the shapes in their memories. The names were then associated with the images of their respective shapes, and with nothing more. These subjects were in the minority, however, and learning for most subjects seemed to be a direct function of speed and adequacy of verbal association.

It must be stressed that the preceding discussion refers only to the initial learning process. Whether these associative processes have any relation to the transfer process is unknown. Subjects readily described the character of the associations which took place during the initial learning process, but they became quite vague when they were asked whether associations helped them to transfer from one

modality to the other.

A hypothesis which might be advanced is that during initial learning some sort of concept was built up corresponding to each stimulus object. These concepts could then be readily identified with the perceptions of their respective stimulus objects, regardless of the sense modality employed in the perception. If this was the case, then the transfer would depend upon the completeness of the concept, and nothing more. This is not to say that no more learning could occur during the transfer trials, for obviously it did, but rather that what was transferred across sensory modalities was virtually equal to what had been learned.

This leads to the question of whether we are really dealing with transfer in the traditional meaning of that term, or whether the Gestalt term "transposition" would not be more applicable. The Gestalt concept of transposition as it appears in Hilgard (5, p. 205) is as follows.

> "A pattern of dynamic relationships discovered or understood in one situation may be applicable to another. There is something in common between the earlier learning and the situation in which transfer is found, but what exists in common is not identical piecemeal elements, but common patterns, configurations, or relationships."

The "pattern" or "configuration" here would correspond to the"concept" discussed above, and whether it be a verbalization, a mental image, or a combination of both is of no consequence so far as the Gestalt theory of transposition is concerned.

The matter of whole versus parts brings up another observation. While most subjects seemed to differentiate the stimulus objects on the basis of their total shape properties, there were some who seem to have employed part detail features for this purpose. That is, the position of certain protuberances or hollows were the primary cues for identification. This, however, led to certain characteristic errors of confusion.

One such instance was the persistent confusion of the shapes "John" and "Bill" by one of the subjects. When the task was over, he was asked how he was finally able to differentiate between the two. He answered that he had confused them because they both came to a point on the right side, but he finally learned that "John" came to a sharper point than "Bill." The fact that "John" was triangular, and "Bill" was diamond shaped apparently never occurred to him.

Some qualitative differences in size were reported by the subjects in connection with vision versus touch. The objects usually felt bigger than they looked. Also, contour features were generally more exaggerated to touch than to vision. This may have some bearing on the differences in degree of transfer discussed earlier. If the bumps and hollows were more prominent to touch, then perhaps those who learned by touch were able to perceive more of the salient features of each stimulus object than those who learned by sight.

Suggestions for Further Research

The extent to which the phenomenon of intermodal transfer is common throughout the general population might be studied. This study was done on college students, and if intelligence should be a vital factor, then the results could hardly be generalized to include the rest of the population.

The perceptual processes are known to be different in young children and in old people than in young and middle-aged adults. An ontogenetic study of intermodal relations is thus indicated.

Brain injuries would be expected to influence performance on a task such as the one used here. A qualitative and quantitative study of the performance of brain injured subjects might give fruitful results.

Further study could be made of the role of form in the visual perception of objects. If the stimulus objects were of different colors, less attention might be paid to shape in making discriminations, and the difference would show up as a reduction in the degree of intermodal transfer.

The effect of practice in form discrimination could be investigated by using an alternate set of stimulus objects. If such practice is effective, then practice on the one set should result in more efficient learning of the alternate set. This would help settle the question as to whether practice, as such, is an important factor in intermodal transfer.

Size and shape constancy could be tested to find out whether constancy phenomena would hold up under conditions of intermodal transfer.

Chapter V

SUMMARY AND CONCLUSIONS

To recapitulate the experiment, eighty-six subjects were tested for evidence of transfer of shape recognition between the sensory modalities of touch and vision. Half the subjects learned to differentiate and recognize twelve stimulus shapes by touch, and were then tested for transfer of recognition to sight. The other half learned first by sight, and were tested for transfer to touch. Statistical analysis of the quantitative data led to the following interpretations.

(1) The recognition of a given set of shapes, learned through touch, may be transferred across modalities to the sense of sight. Transfer also occurs from sight to touch, and the degree of transfer is very great in both instances.

(2) Under the conditions of this experiment, touch and vision are equally efficient in learning to differentiate and recognize the given shapes.

(3) Transfer is significantly greater in going from touch to vision than in going from vision to touch.

(4) The rate of initial learning in shape discrimination and recognition does not have any significant correlation with the degree of transfer which takes place. That is, slow learners transferred just as well as fast learners.

Of the conclusions to be inferred from these experimental results, the most obvious one is that transfer of shape recognition across sensory modalities does take place. The manner in which it takes place, however, is of much greater interest than the mere fact of its occurrence.

The degree of transfer was much greater than would be expected if learning through one sense modality had only a facilitative effect on learning through the other sense modality. The evidence, in this case, points toward a rather complete carry over to the second modality, of what was learned through the first modality. A conclusion to be drawn from this is that "transfer" in the traditional psychological meaning of the term may not be applicable to this situation. That is, rather than a carry over of aspects or elements in the recognition of the stimulus shapes, there seemed to be a virtually complete transposition of recognition from the first sensory modality to the second.

Since normal adults usually depend more upon vision than upon touch for perceptual contact with objects in their everyday environment, one would expect vision to be more

efficient than touch in learning to distinguish unfamiliar shapes. The results of this experiment do not bear out this assumption, for on the initial learning task, those who learned by sight were no more efficient than those who learned by touch. Nevertheless, any conclusions about equivalence of the two senses in learning to discriminate shape must be limited, for the time being, to shapes of a size and complexity similar to those employed in the experiment. However, the evidence seems strong enough to support the conclusion that the perception of shape, as such, is not exclusively a visual function.

With regard to the greater efficiency of transfer in going from touch to vision than vice versa, there seems to be no explanation beyond that which would be speculative. Tentative hypotheses were offered in Chapter IV, but in view of the paucity of data, no conclusions seem warranted.

The lack of significant correlation between rate of learning on the initial task of discrimination, and the degree of transfer, lends further support to the conclusion that what is carried across modalities is not merely the effect of practice in shape discrimination. The above datum, coupled with the observation that specific errors as well as correct responses were transferred across modalities, leads to the following tentative conclusion. The recognition of a shape by the second modality depends upon the completeness of the

concept of that shape built up through the first modality.

The conclusions stated above are the only ones which appear to have sufficient foundation to be stated as such. The extent to which they may be generalized beyond the limits of this study is not yet known, for little work has been done on this topic. It is hoped, however, that the results of this experiment may be provocative enough to open up new research in a hitherto neglected area, and perhaps generate a fresh angle of attack upon current problems in psychological theory.

APPENDIX I

TRIALS,* ERRORS, AND A. C. E. TOTAL RAW SCORES
OF EACH SUBJECT IN GROUP I

Men					Women				
Learning		Transfer		A.C.E.	Learning		Transfer		A.C.E.
T	E	T	E		T	E	T	E	
4	26	0	0	103	3	21	0	0	130
7	37	2	3	131	7	36	2	4	113
3	18	1	1	90	7	35	1	1	131
5	29	0	0	143	7	41	1	1	153
9	59	3	8	94	8	29	2	4	141
7	30	2	3	99	7	17	3	6	150
11	78	1	1	--	10	50	1	1	108
9	43	0	0	--	5	27	0	0	126
5	27	1	1	--	12	34	0	0	120
13	97	4	11	--	10	37	0	0	118
5	26	0	0	121	9	49	2	4	101
9	46	1	2	--	11	62	1	1	106
6	23	1	1	142	8	45	1	3	103
3	14	0	0	--	15	69	1	1	--
9	37	0	0	--	8	27	0	0	--
9	30	1	1	--	7	24	2	4	--
6	31	1	1	--	10	46	2	3	118
6	37	0	0	--	11	44	3	9	--
10	64	1	4	--	14	80	1	3	--
6	26	0	0	--	12	73	1	1	--
6	31	1	3	--					
5	25	1	1	--					
7	25	0	0	--					

* Errorless criterion trials are not included.

APPENDIX II

TRIALS,* ERRORS, AND A. C. E. TOTAL RAW SCORES OF EACH SUBJECT IN GROUP II

Men					Women				
Learning		Transfer		A.C.E.	Learning		Transfer		A.C.E.
T	E	T	E		T	E	T	E	
7	27	0	0	148	5	23	0	0	--
12	74	7	14	68	14	76	2	6	101
4	16	2	4	99	7	49	4	12	109
10	64	2	6	81	3	19	4	11	123
9	54	2	5	106	7	25	0	0	94
3	10	2	5	115	3	13	0	0	116
4	33	1	1	--	6	30	1	1	133
8	47	2	6	146	4	14	3	6	111
4	14	1	2	--	5	31	2	5	148
4	16	3	5	77	6	24	3	5	86
10	28	2	3	114	7	41	4	10	--
2	12	3	12	--	8	46	1	2	--
6	36	1	4	--	7	37	4	10	--
6	28	2	2	139	11	61	1	2	--
7	33	1	1	--	7	32	1	1	--
5	18	3	8	--	5	24	0	0	146
11	77	1	3	--	1	3	2	6	117
5	14	3	3	--	5	26	3	8	--
4	18	2	4	--	13	54	4	11	--
11	61	2	3	--	11	63	2	5	--
8	51	5	15	98					
5	27	0	0	--					
8	53	0	0	--					

* Errorless criterion trials are not included.

APPENDIX III

DATA RECORD BLANK

Trials - Learning

	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	Errors
1 Joe	9	/	/	/	/											1
2 Art	-	-	/	/	/											2
3 Sam	/	11	1	/	/											2
4 Bill	/	-	/	/	/											1
5 John	-	-	2	/	/											3
6 Ken	3	-	12	/	/											3
7 George	4	/	/	/	/											1
8 Paul	-	12	/	/	/											2
9 Zeke	/	/	/	/	/											0
10 Lem	-	-	/	/	/											2
11 Al	4	-	/	/	/											2
12 Tim	-	6	/	/	/											2
Errors	9	9	3	0	0											21

Trials - Transfer

	1	2	3	4	5	6	7	8	9	0	1	2	3	4	5	Errors
1 Joe	/															
2 Art	/															
3 Sam	/															
4 Bill	/															
5 John	/															
6 Ken	/															
7 George	/															
8 Paul	/															
9 Zeke	/															
10 Lem	/															
11 Al	/															
12 Tim	/															
Errors	0															0

REFERENCES

1. Cutsforth, T. D. An analysis of the relationship between tactual and visual perception. Psychol. Monogr., 1933, 44, No. 1 (Whole No. 197).

2. Halstead, W. C. Brain and intelligence. Chicago: University of Chicago Press, 1947.

3. Hartmann, G. W. Gestalt psychology. New York: Ronald Press Co., 1935.

4. Hebb, D. O. The organization of behavior. New York: John Wiley & Sons, Inc., 1949.

5. Hilgard, E. R. Theories of learning. New York: Appleton-Century-Crofts, Inc., 1948.

6. McGeoch, J. A. The psychology of human learning. New York: Longmans, Green and Co., 1949.

7. Ryan, T. A. Interrelations of the sensory systems in perception. Psychol. Bull., 1940, 37, 659-698.

8. Stevens, S. S. Handbook of experimental psychology. New York: John Wiley & Sons, Inc., 1951.

9. Woodworth, R. S. Experimental psychology. New York: Henry Holt, 1948.

10. Worchel, P. Space perception and orientation in the blind. Psychol. Monogr., 1951, 65, No. 15 (Whole No. 332).

BIOGRAPHY

Henry Frank Gaydos was born on February 26, 1922 in New York City. He entered the Georgia School of Technology in 1941, majored in Mechanical Engineering, and received his Bachelor of Science degree in June, 1944.

After serving two years in the armed services, he returned to Georgia Tech., where for two years he held the position of Instructor in the Mechanics Department. During this time, he began his graduate studies in psychology at Emory University, where he received the degree of Master of Arts in August, 1949.

In February, 1950, he entered the University of Florida to continue his studies in psychology at the doctoral level. During that time he held graduate assistantships in the Psychology Department, and was also employed as part-time clinician in the Psychological Clinic.

He is an associate member in the American Psychological Association, and is a member of Alpha Kappa Delta Honorary Sociology Fraternity.

This dissertation was prepared under the direction of the chairman of the candidate's supervisory committee and has been approved by all members of the committee. It was submitted to the Dean of the College of Arts and Sciences and to the Graduate Council and was approved as partial fulfilment of the requirements for the degree of Doctor of Philosophy.

August 10, 1953

C. F. Byers

Dean, College of Arts and Sciences

L. E. Grinter

Dean, Graduate School

SUPERVISORY COMMITTEE:

J. C. Dixon

Chairman

Henry Wunderlich

R. F. Anderson

T. Lynn Smith

W. W. Ehrmann